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Improvement of Power Quality by using Advanced Reactive Power Compensation

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ABSTRACT

The maximum power point tracking controller is an essential part of the photovoltaic system and uses its algorithms to obtain the maximum available power of the PV array under various environmental conditions. This paper provides a brief overview of the main MPPT techniques. A particle swarm optimization (PSO) algorithm was used to automatically find the parameters and improve the performance of the controller. The system was simulated and tested in the MATLAB/Simulink environment, the PSO algorithm was run in the m-file and the system was simulated hundreds of times to achieve the best results presented in this paper. This article introduced the most common techniques for PV systems to monitor MPP. Proper implementation and design of MPPT technology can greatly improve the efficiency of the energy conversion process and prevent energy losses due to environmental changes. This white paper serves as a practical guide not only for MPPT researchers, but also for designers of commercial PV systems.

KEYWORDS: *Photovoltaic System (PV), MPPT, PSO, DC-DC Converters, Micro-Grid (MG)*

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INTRODUCTION

Many metal industries use electric arc furnaces (EAF) to produce steel. It is important to study the impact on power quality [1]-[3]. Generally, there are three periods in the EAF operating process: drilling, smelting, and refining. After preheating with the torch, lower the electrode and turn it on [4]. During the drilling and melting period, the arc current changes dramatically as the scrap continuously melts and irregularly collapses between the graphite electrodes. As a result, the EAF states randomly change between short circuit, open circuit and non-linear arc models [5]. The main obstacles in EAF are voltage flicker, load unbalance and harmonics [1]-[6]. Excessive levels of power unbalance and negative sequence currents are caused by arc re-ignition faults [7]. Unbalanced loads can cause unwanted reverse currents in 3-phase, 3-wire systems. This negative series current causes additional losses from generators, transmission lines and transformers. There are many techniques for tuning static var compensators (SVCs) in three-phase systems, which are presented in [8,9]. The susceptance of each phase of the SVC can be obtained from the rms values of the voltage and current of the three-phase load. The SVC compensation algorithm can balance the three-phase loads and improve the power factor to unify the fundamental component [8, 10].

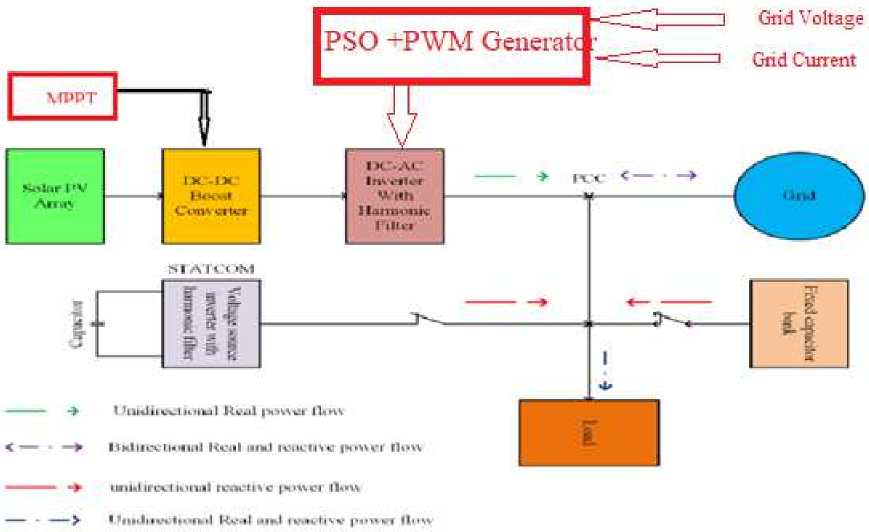

Fig-1 Block diagram of proposed solar system

Grid connected Solar PV array with STATCOM and MPPT:

A system of photovoltaic modules can be created by parallel and series integration of different photovoltaic modules. Series connection of photovoltaic panels increases the terminal voltage of the photovoltaic panel array and parallel connection of the photovoltaic panel arrays increases the nominal current of the photovoltaic panel array. The rated power of one module is 213.15 W, the maximum point voltage of the PV module is 29 V, the no-load voltage of the PV module is 36.3 V, and the short-circuit current of the PV module is 7. 84A, the maximum power of the cutter is 7.35A. The PV modules connected in series are 10, the PV modules connected in parallel are 47. The total power of the PV array is 100.345 kW, the PV modules open circuit voltage is 363 V, the PV short circuit current is 368 V.

PSO algorithm:

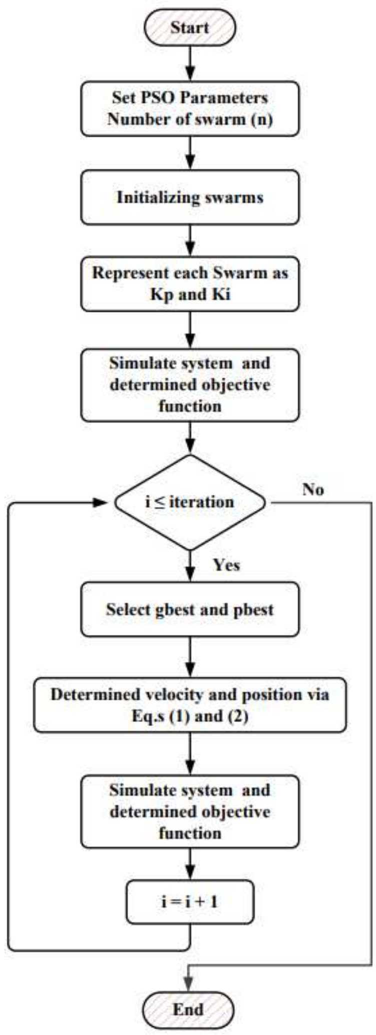

Fig-2 Flow chart for proposed PSO method

The PSO algorithm is considered one of the best optimization techniques and is superior to other optimization techniques in terms of ease of implementation, robustness, and ability to converge globally. For these reasons, the PSO algorithm was chosen for this paper. In this way, we can check the convergence of the algorithm and find the optimal value of the objective function [18-19]. The principle of the PSO algorithm depends on its two factors: speed and position. Members represent these updated factors using formulas (1) (2).Figure 2 shows the flowchart of the proposed optimization procedure.

$$V_i^d(t+1)=wV_i^d(t)+c_1r_1\left(P_t^d(t)-X_i^d(t)\right)+c_2r_2\left(P_t^d(t)-X_i^d(t)\right) \quad (1)$$

$$X_t^d(t+1)=X_i^d(t)+V_i^d(t+1) \quad (2)$$

Where, $c1$ is social rate and $c2$ is cognitive rate. $r1$ and $r2$ is the random interval (0,1). V is the velocity w is the inertia factor. X is the Position factor.

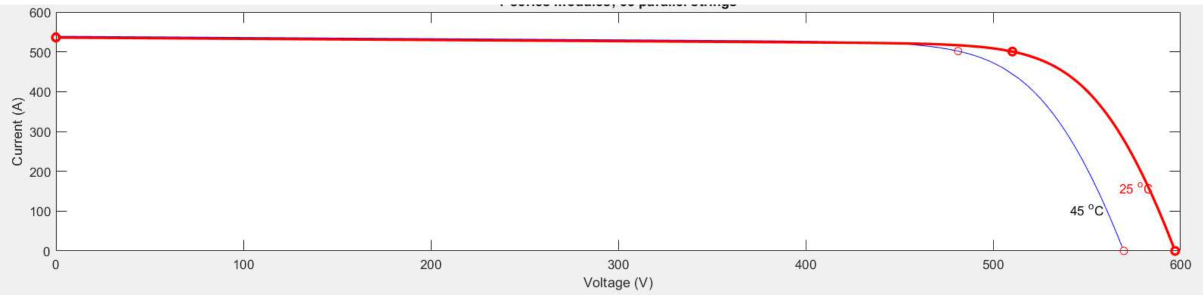

Fig-3 V_I Charecteristics of solar array

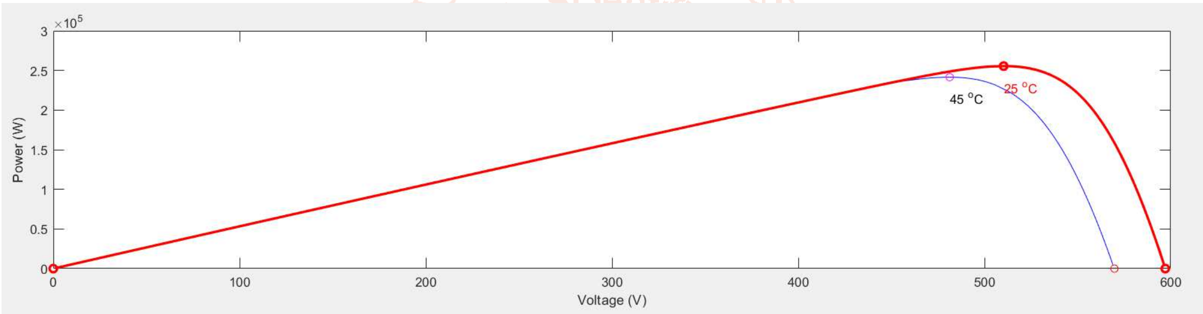

Fig-4 P_V Charecteristics of solar array

Shunt Compensation:

In shunt compensation, the power system is connected in parallel (parallel) to the FACTS. This acts as controllable current source shunt balancing as shown in figure (5). There are two types of shunt compensation. The shunt capacitance is used to improve the power factor. If the load connected to the line is lagging, shunt capacitance compensation is most often used, since commonly used loads are inductive in nature. Shunt inductance compensation is used in long transmission lines where the Ferranti effect occurs because the voltage capacitance at the receiving end of the transmission line increases. As the inductance is shifted, the transfer capacitance increases. It is obvious that the required power can be supplied by controlling the angle of the thyristor connected to the power line according to the required power and thus alternating current can be supplied to the transmission line. You can control the current injected into series compensation and control the voltage injected into parallel compensation STATCOM and D-STATCOM FACTS technology is an application of power electronics in transmission line systems. The main purpose of this technology is to control and regulate electrical variables such as (current, voltage, impedance) to effectively compensate voltage drops in power systems. Rapid advances in power electronics technology are increasingly expanding the use of power electronics devices at various voltage levels in electrical power systems. STATCOM is one such device that could potentially be used in case of its transmission level FACTS and distribution level power limit controller as well as in end user electrical installations. Potential related applications include voltage regulation, power factor correction, load sharing, and harmonic reduction. DSTATCOM is a voltage converter (VSC) based power electronics device. This device is normally backed up by energy temporarily stored in a DC capacitor. The DSTATCOM filters the load current to meet the grid connection specifications.

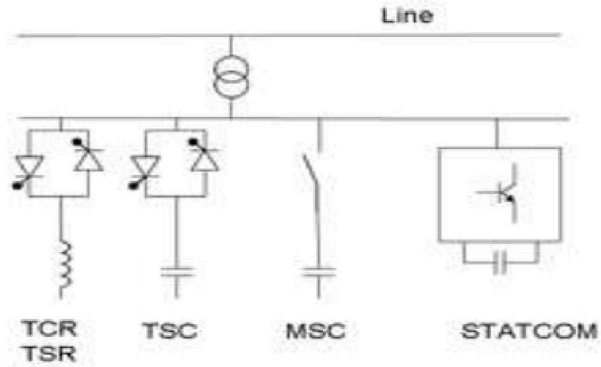

Fig 5-Shunt compensation

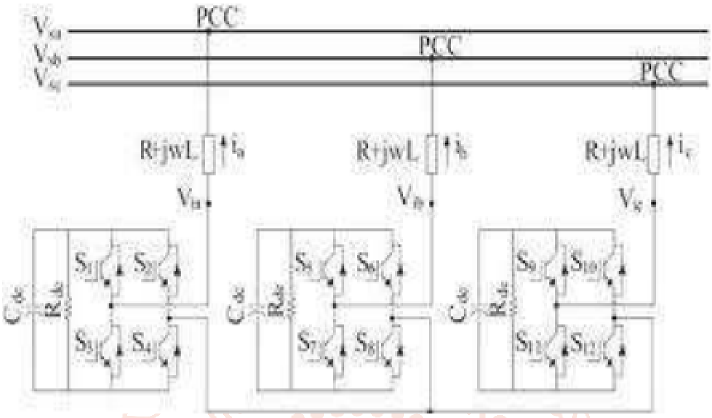

Fig-6 STATCOM used for power injecting in three phase transmission line

The voltage to inject in the transmission line in each phase:

$$P_s = P_r = V \cos(\delta/2) * \frac{2V \sin(\delta/2)}{X} = \frac{V^2}{X} \sin(\delta/2) \quad (3)$$

$$Q_s = -Q_r = V \sin(\delta/2) * \frac{2V \sin(\delta/2)}{X} = \frac{V^2}{X} * (1 - \cos(\delta)) \quad (4)$$

These two equations describe the flow of active and reactive power in a transmission line. Both powers also depend on line reactance and power factor. Therefore, it can be controlled by reducing the influence of the inductance of the transmission line.

Result: To justify our aim MATLAB results have been shown in Fig-7 – 15.

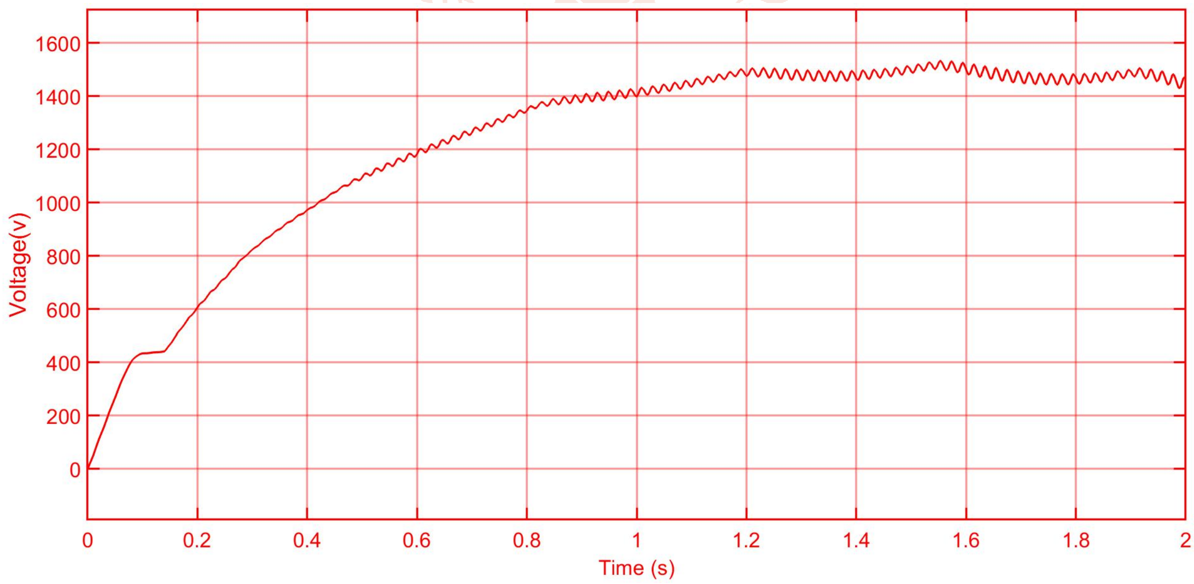

Fig-7 Solar Voltage (With STATCOM and MPPT)

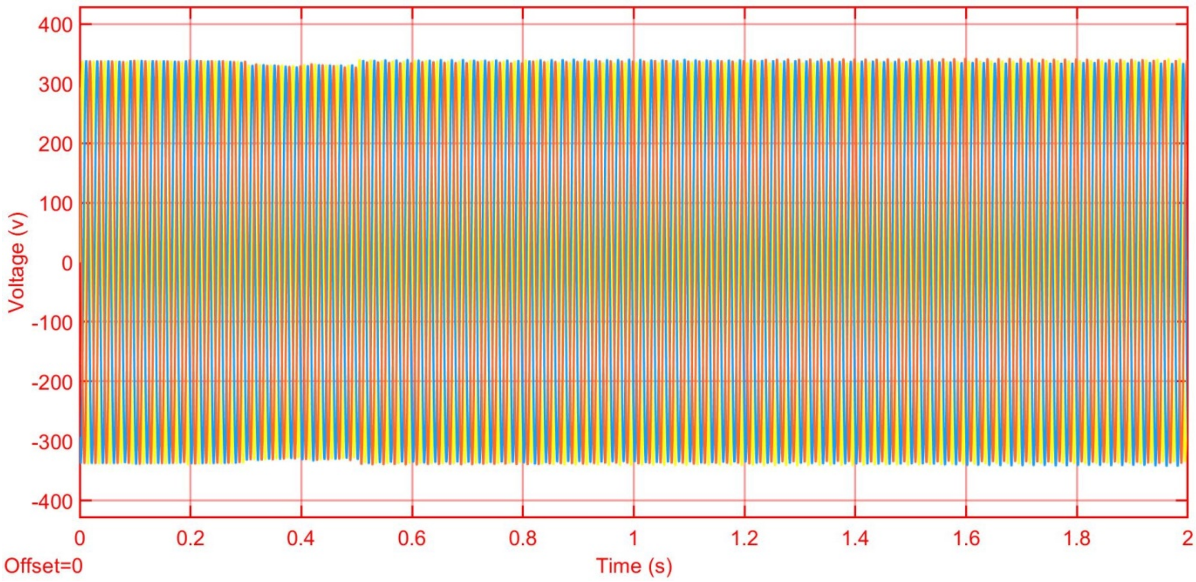

Fig-8 Grid Voltage (With STATCOM and MPPT)

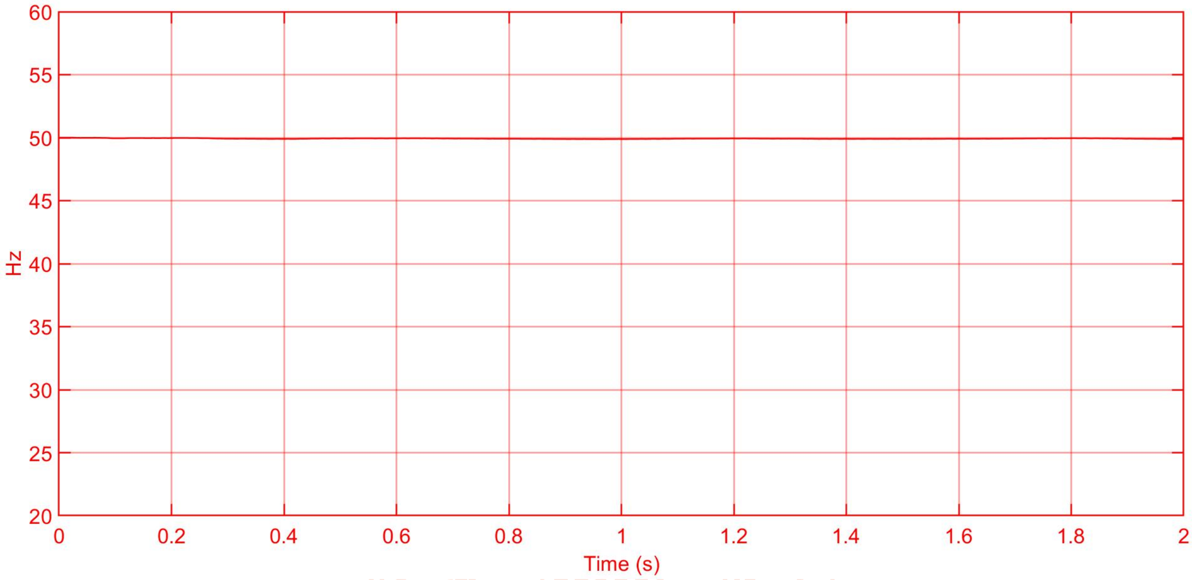

Fig-9 Frequency of grid (With STATCOM and MPPT)

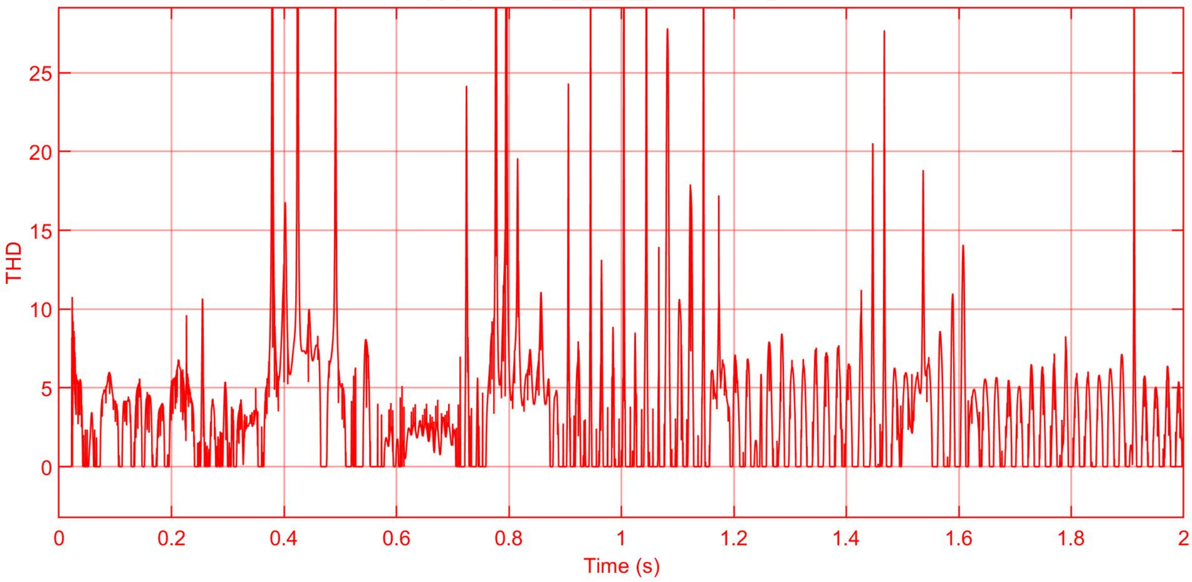

Fig-10 THD (With STATCOM and MPPT)

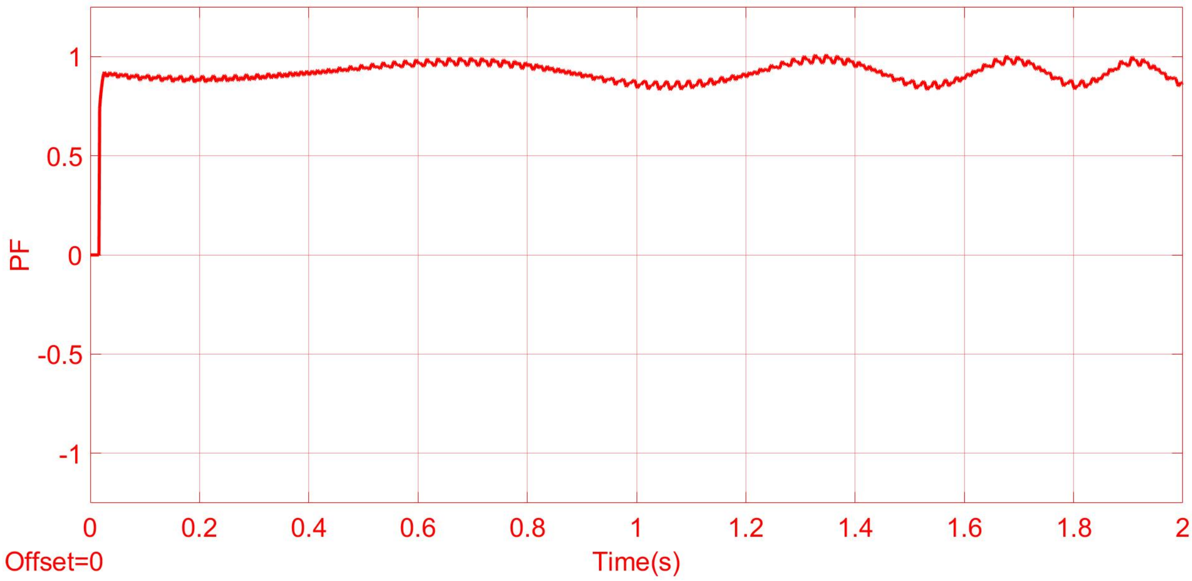

Fig-11 Power Factor (With STATCOM and MPPT)

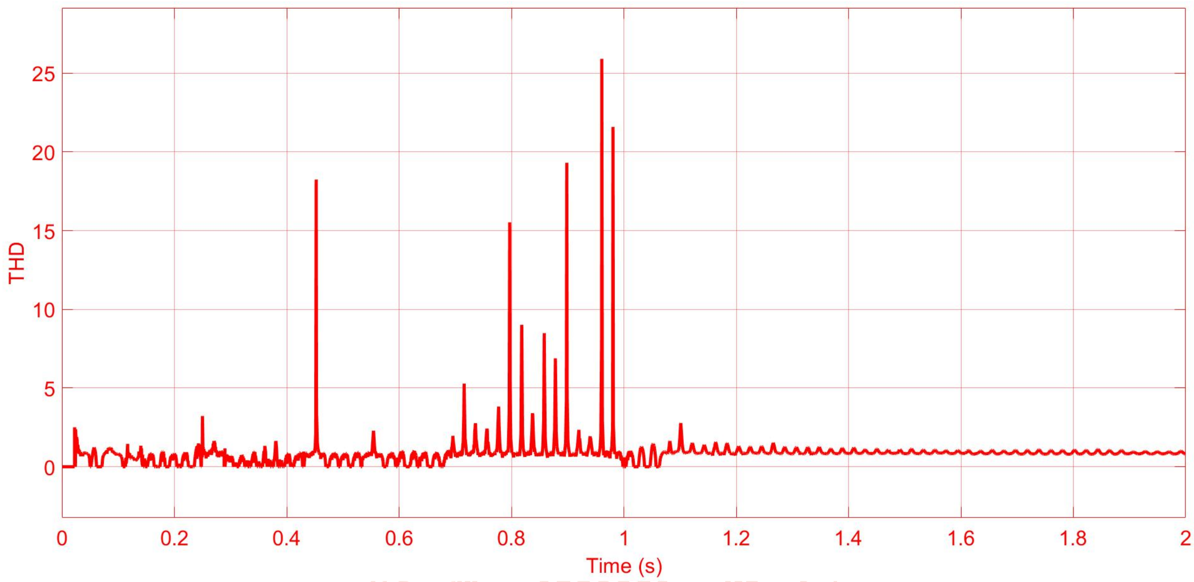

Fig-12 THD(Without STATCOM and MPPT)

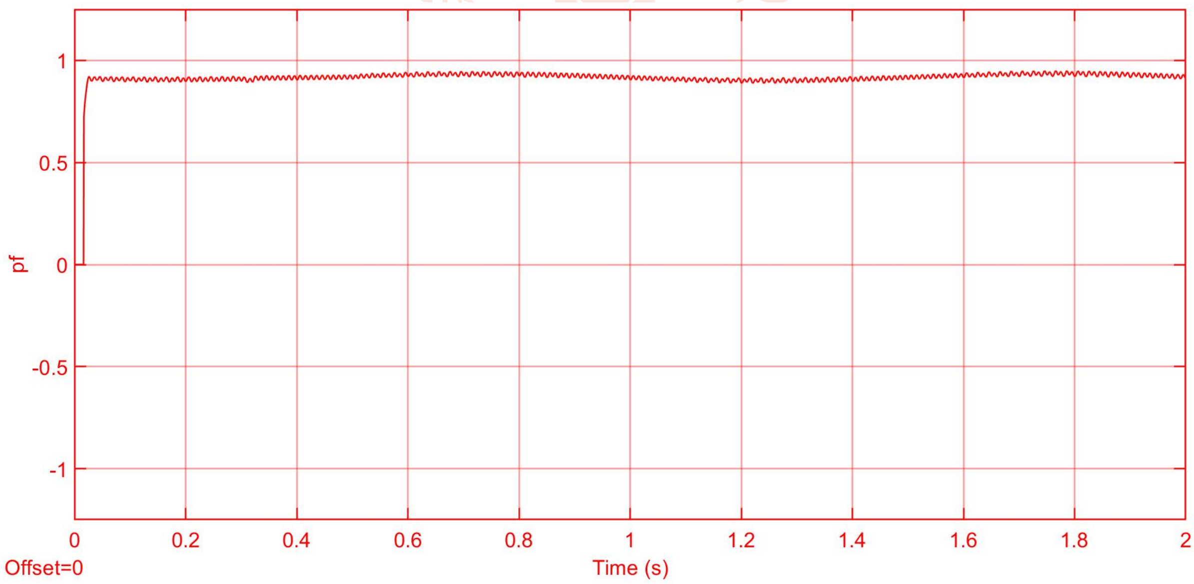

Fig- 13 Power Factor (Without STATCOM and MPPT)

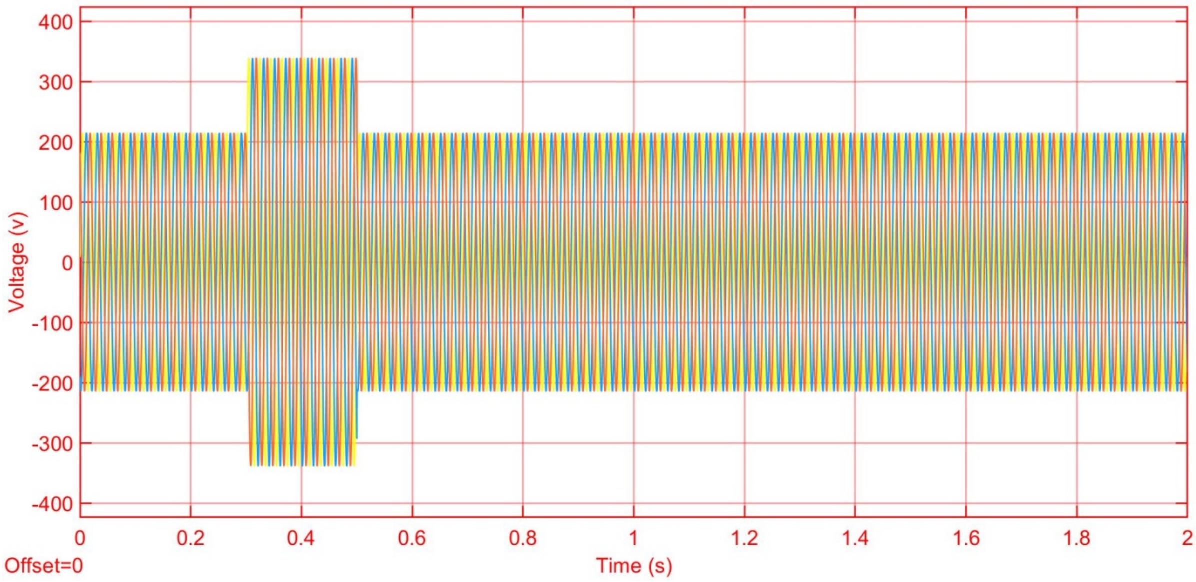

Fig 14 Grid Voltage (Without STATCOM and MPPT)

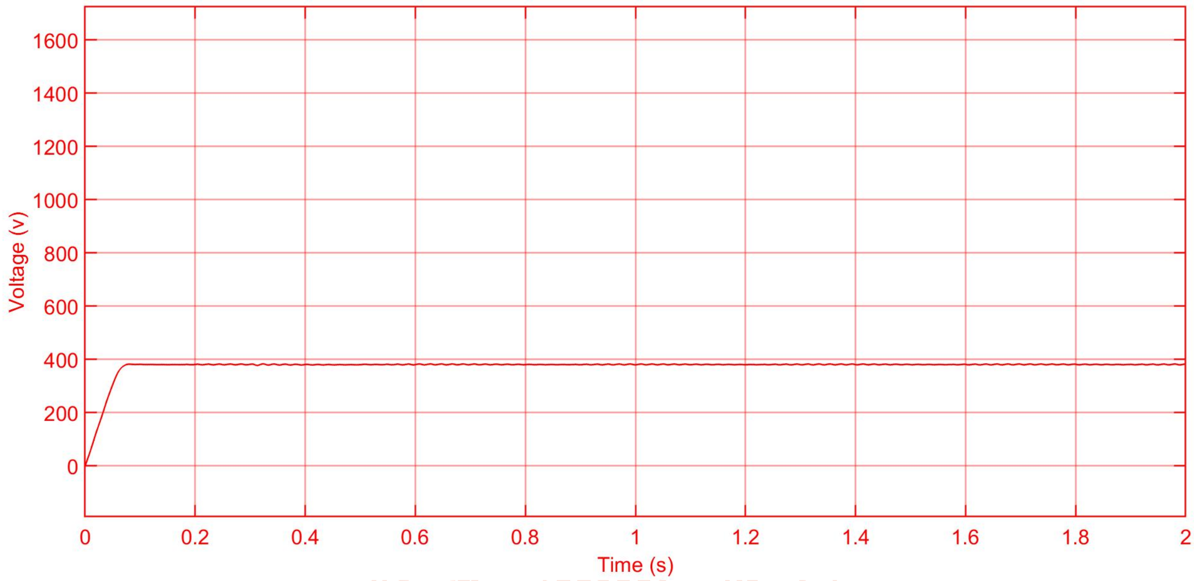

Fig -15 Solar array voltage (Without STATCOM and MPPT)

Conclusion:

The system was simulated and tested in the MATLAB/Simulink environment, and the PSO optimization integrated in the M-file was called from Simulink to find the minimum network performance value. The PSO algorithm has shown an excellent way to find the best trades for Ig and Vg, but it seems impossible for humans to achieve optimal values. The simulation results for both voltage and current output curves are stable with reasonable THD for both controllers, but one still outperforms the other. Interrupting and monitoring drivers is very easy and fast. A disadvantage of the P&O algorithm is that the system's steady operating point oscillates around its MPP, wasting available energy. The choice of the perturbation step size is very important. The step size determines how quickly the MPP is reached. Faster tracking can be achieved with a larger step size, but the oscillation around the MPP increases. There is a trade-off between dynamic performance and stable performance.

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